CONCEPTUAL MODELS FOR HIGH $PM_{2.5}$ and PM_{10} IN CENTRAL CALIFORNIA

Dr. John G. Watson
(johnw@dri.edu)
Desert Research Institute

Wintertime Clear Sky Stagnation and Stagnation with Fog

- Not separate phenomena. Fog and clear skies occur together at different times and places. Fog prevalent over moist surfaces due to irrigation or prior precipitation. Fog is depleted over urban heat islands.
- Occurs in winter, mid-November to mid-February, under high pressure system punctuated by frontal passages and precipitation.
- Less frequent wintertime storm systems lengthen PM buildup period and number of exceedances. Also result in drier surfaces with less vegetative cover in summer and fall.

Clear Sky Stagnation and Stagnation with Fog

- PM10 is driven by PM2.5. Coarse particles (fugitive dust, pollen, spores) <10% of PM10.
- PM2.5 is 80% to 90% ammonium nitrate and carbon.
- Nearly all carbon is from primary emissions, mostly in cities, from vehicle exhaust, residential heating, and cooking in the cities. Residential heating is the largest contributor. Secondary organic carbon is negligible.
- Secondary ammonium nitrate is regionally distributed.
- Ammonium nitrate is limited by nitric acid availability rather than ammonia. The cross-over point is ____.

Clear Sky Stagnation and Stagnation with Fog

- Nitric acid formation is limited by VOC rather than NOx availability. The cross-over point is ____.
- Primary emittants accumulate under a shallow (20 –30 m) radiation surface layer from 1700 PST to 1000 PST the following day.
- Pollutants between the top of this layer and the valleywide layer (300 m to 1000 m) circulate throughout the SJV at 1 to m/s during this period.
- The surface layer minimizes deposition to the surface.
- The surface and valleywide layer couple rapidly at ~1000 PST, bring aged pollutants to the surface and injecting primary pollutants aloft.

Clear Sky Stagnation and Stagnation with Fog

- Photochemical reactions create HNO3 aloft, beginning soon after sunrise.
- HNO3 is also produced aloft at night owing to lack of fresh NOx and abundant H20.
- Nighttime transport without deposition mixes HNO3 from precursor emissions in cities and roadways with NH3 from non-urban areas.
- Industrial stacks inject NOx directly above the surface layer, regardless of time of day.
- Fogs enhance sulfate production, but lack of SO2 precursors keeps this low.
- Fog droplets absorb nitrate and deposit to the ground. Fogs tend to reduce PM2.5.

Clear Sky Stagnation and Stagnation with Fog

- Further SO2 reductions (expected from diesel fuel changes) will not cause increases in ammonium nitrate as there is sufficient NH3 to neutralized all acids at wintertime temperatures and RH.
- Low offshore pressure gradients often create upvalley flows, resulting in PM2.5 transport from the SJV into the Bay area.
- Little PM2.5 is transported from the Bay area into the SJV.

Fall Suspended Dust and Nitrate

- Highest PM10 and PM2.5 occur in a sub-region centered on the Tulare Lake bed.
- Both PM2.5 and coarse particles are present. Reducing only PM2.5 does not solve the PM10 problem.
- Fall nitrate may be limited by ammonia availability near strong ammonia sources, especially south of Fresno where a nitric acid cloud encounters intense agricultural NH3 sources. (Rubidoux situation).
- Primary carbon emissions from vehicle exhaust accumulate in cities, especially at night, but to a lesser extent than during winter. Home heating emissions are less important than during winter.

Spring Windblown Dust

- Frontal passages create high winds that pass over unvegetated surfaces. This is more common following a dry winter than a wet winter.
- Sporadic cold nights result in short-term extensions of wintertime clear sky stagnation without multi-day buildups.

Summer

- High temperatures and low humidities shift ammonium nitrate equilibrium to gas phase (which also results in nitrate losses on FRM samples).
- Primary carbon emissions dominated by vehicle exhaust.
- Few PM2.5 exceedances are observed, but O3 standards are exceeded.